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THE USE OF OPAQUE LOUVRES AND SHIELDS TO REDUCE REFLECTIONS WITHIN THE COCKPIT: COMPUTER PROGRAMS FOR TWO APPROACHES TO THE PROBLEM

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Opaque shields can be used to channel light and thereby reduce reflections within the cockpit. These shielding devices range from the standard glare shield on top of the instrument panel to the more experimental use of Light Control Film[R] and Micromesh[R] for this purpose. Previous work in this series has demonstrated two mathematical approaches to a specific reflection problem in the AH-1 aircraft, namely, the reflections coming from the portion of canopy directly above the gunner's head. It was felt that it would be useful to demonstrate the compatibility of these two approaches and to publish

the computer programs (FORTRAN) for each approach for possible use by others.

SUMMARY

Opaque shields can be used to channel light and thereby reduce reflections within the cockpit. These shielding devices range from the standard glare shield on top of the instrument panel to the more experimental use of Light Control Film[R] and Micromesh[R] for this purpose. Previous work in this series has demonstrated two mathematical approaches to a specific reflection problem in the AH-1 aircraft, namely, the reflections coming from the portion of canopy directly above the gunner's head. It was felt that it would be useful to demonstrate the compatibility of these two approaches and to publish the computer programs (FORTRAN) for each approach for possible use by others.

Robert W. Bailey

ROBERT W. BAILEY
COL, MSC
Commanding

INTRODUCTION

One technique of reducing the reflections of the instruments, dials, etc. from the transparent enclosures is the use of opaque louvres and shields. In using these screening materials, one wants to maximize the extent to which they block light from reaching the canopy but minimize the extent to which they block light from reaching the pilots' eyes. This is accomplished by choosing the proper values for the position, width, spacing, angle, etc. of these shields.

In a previous report[1] we showed a set of mathematical equations for the solution of this problem in terms of analytic geometry. Quite independently, the problem has also been investigated by a different mathematical method, namely a plane geometrical and trigonometrical method. The latter method will be documented elsewhere[2]. Regardless of the different mathematical derivations, results from these two theoretical predictions of the reduction in interior cockpit reflections were essentially identical. The purposes of this report are to demonstrate the compatibility of these two theoretical predictions and to document these two FORTRAN computer programs.

ANALYSIS

Due to the nature of the problem, visibility has been classified

into three cases. We denoted the projected points of the lower and higher points of the louvre to the vertical axis of the pilot's position by h and H respectively. Case I concerns the visibility V_I above H. Visibility V_{II} (Case II) is the region between H and h. Below h, visibility V_{III} is classified as Case III. Since Case II is relatively trivial and since Case III is similar to Case I, we will show the equations for Case I by these two methods.

a. Analytical geometry method:

$$V_{I_A} = 1 \; \frac{d_1}{c} \; \frac{\tan\Theta - k_1}{1 + k_1 \tan\Theta} \qquad \text{(A)}$$

Where V_{I_A} is visibility, c is the distance between louvres, d_1 is the thickness of the louvre, Θ is the decline angle of the instrument panel and k_1 is constant. All the symbols were explained in the original paper and are shown in Appendix I (incorporated with notations in the computer programs).

b. Plane geometrical method:

$$V_{I_B} = K \; \frac{1\ (h-H)\ (\mathrm{Cot}^{\alpha}\ \mathrm{Cos}\ \Theta + \mathrm{Sin}\ \Theta)}{h\ \sec\ (\alpha-\Theta) - 1 - \alpha\ \sin\ \Theta\ \sec\ (\alpha-\Theta) - (h-H\ \mathrm{Cos}\ \Theta\ \mathrm{Sin}\ \alpha)} \qquad \text{(B)}$$

Where V_{I_B} is visibility, K is constant, h is the minimum height, H is the maximum height, Θ is the decline angle of the instrument panel and α is the extended angle.

A detailed explanation of the symbols in this equation is also given in Appendix II.

SOLUTION

Computer programs for equations (A) and (B) are attached in Appendices III and IV respectively. Comments and notations used have been added in the programs except for the graphic portion of the programs, which required a few calls from standard subroutines, and were plotted through a hybrid computer plotter[3].

Results from both methods have been represented by two graphs (Figures 1 and 2 correspond to methods (A) and (B) respectively.). They were indistinguishably identical. (The vertical axis showed the normalized visibility and the horizontal axis was the vertical distance with respect to a referenced ground point in the Cartesian coordinates system. There are six curves in each graph with each curve representing a different louvre width. These graphic representations enabled us to determine the amount of visibility of a pilot under a set of predetermined cockpit parameters.

In short, this study has presented two different mathematical formulations which produced identical solutions for the analysis of the use of opaque louvres and shields to reduce reflections within the cockpit. It has also documented two computational procedures with their respective computer programs for future analyses of cockpit light reflections.

CONCLUSION

Previous work in this series has demonstrated two mathematical approaches to a specific reflection problem, namely, the reflections coming from the portion of canopy directly above the gunner's head. Although these two studies addressed a specific reflection problem, they each represented the modulus of a general approach to the canopy reflection problem. Therefore, it was felt that it would be useful to demonstrate the compatibility of these two approaches and to publish the computer programs for each approach for possible use by others.

RECOMMENDATIONS

In future canopy design, it is recommended that an analysis of this sort be carried out prior to fabrication of the canopy and cockpit. In this way, some potential reflection problems could be prevented without having to initiate costly re-designs and product improvement programs.

REFERENCES

1. Chiou, W.C. and Holly, F.F., "The Use of Opaque Louvres and Shields to Reduce Reflections Within the Cockpit: A Mathematical Treatment", USAARL Report NO. 75-22, June 1975.

2. Park, C.K. and Holly, F.F., "The Use of Opaque Louvres and Shields To Reduce Reflections Within the Cockpit: A Trigonometrical and Plane Geometrical Approach," USAARL Report NO. 76-4, Sep 75.

3. We thank Dr. H.D. Jones of the Hybrid Computer and Analysis Branch, USAARL, for establishing the plot portion of the computer programs.

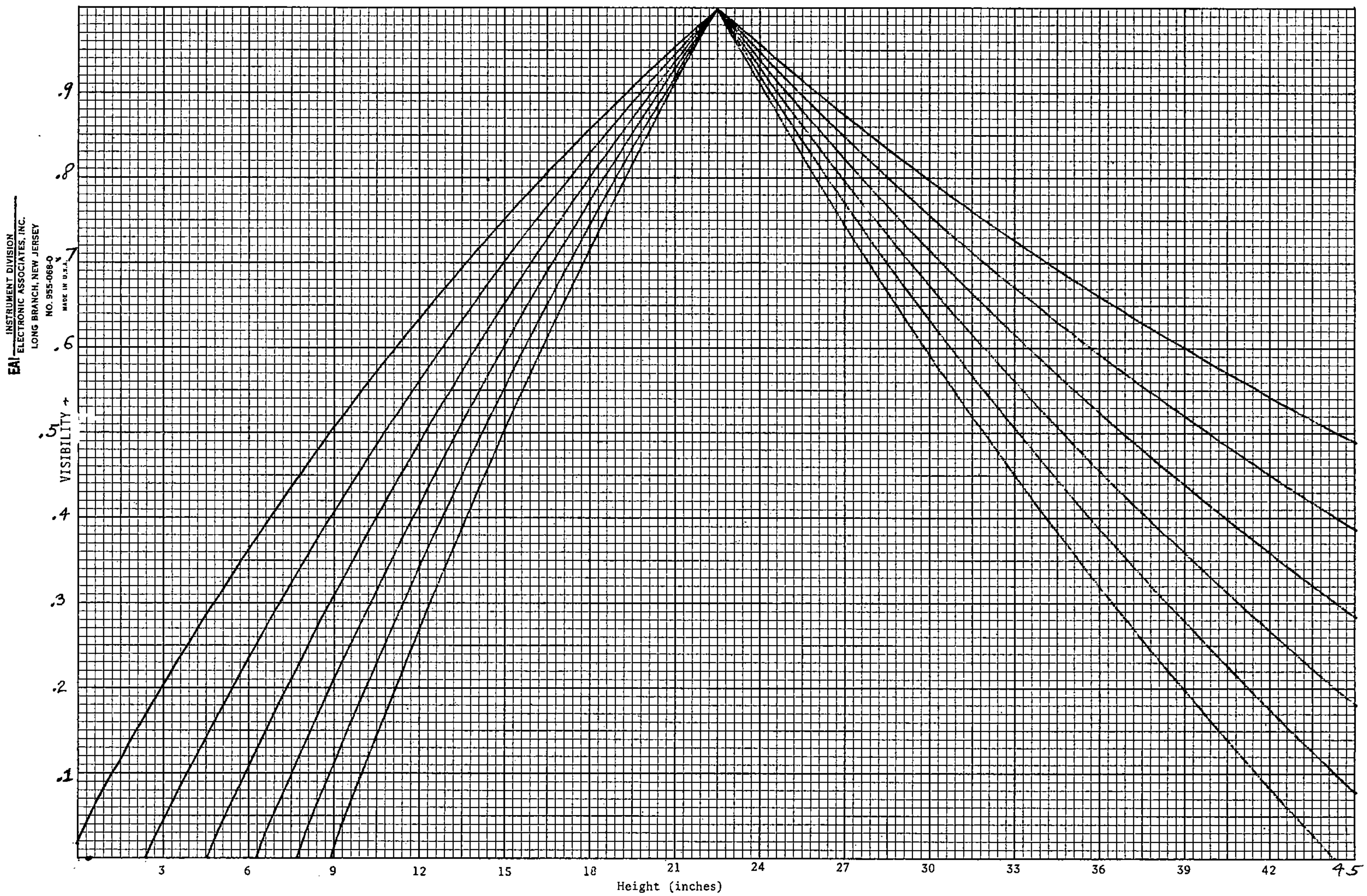

FIGURE 1. Visibility as a function of height in the plane of the gunner as determined by the method of analytic geometry.

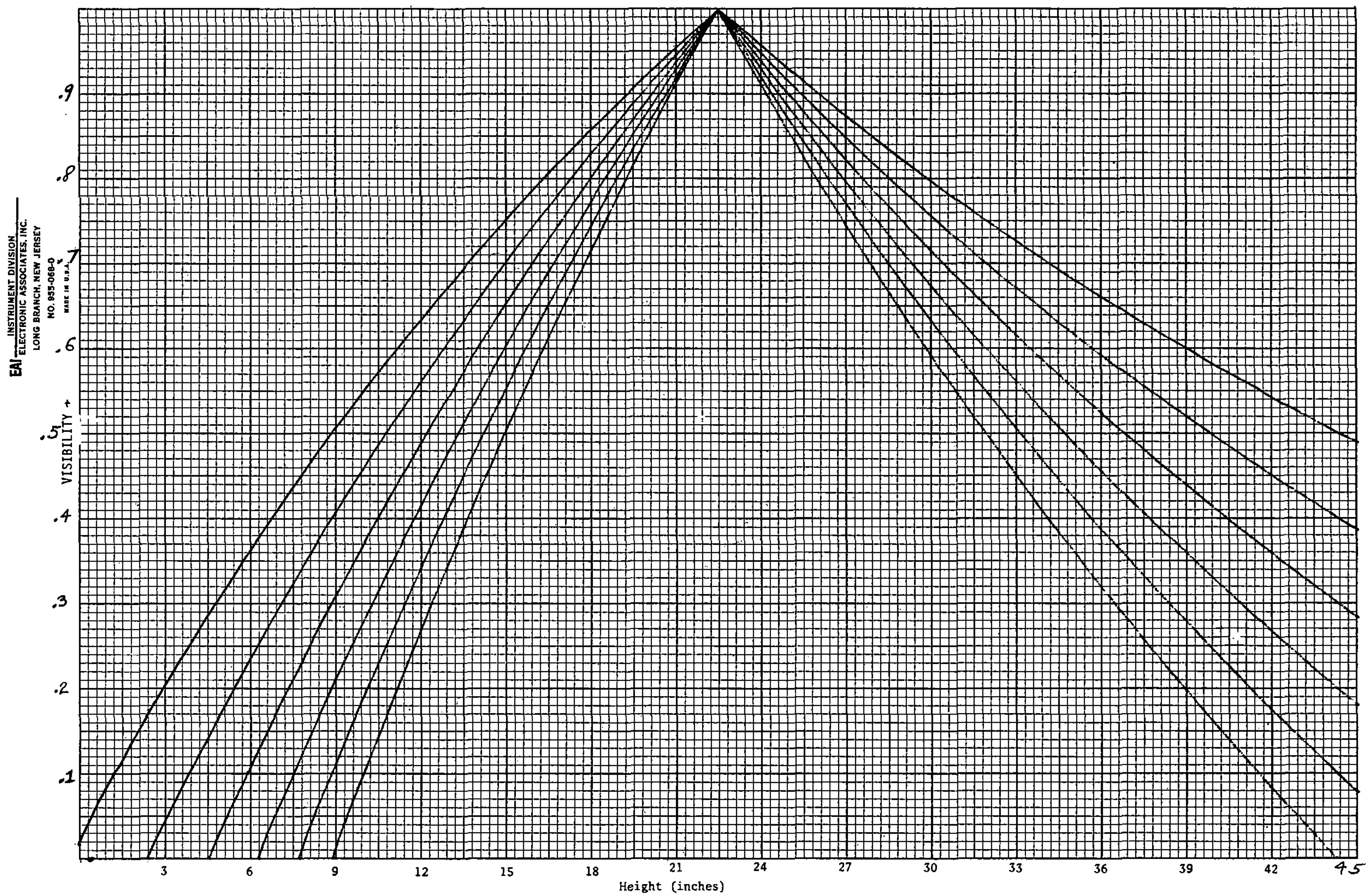

FIGURE 2. Visibility as a function of height in the plane of the gunner as determined by the method of plane geometry.

APPENDIX I

ANALYTICAL GEOMETRY METHOD

COL. (4 Decimal)	INPUT CODE	SYMBOLIC CODE	HEADER CODE	COMMENT
1-7	A	a	A	Distance from panel
8-14	B	b	B	Distance the louvre is up the panel
19-21	C	c	C	Distance between the louvres
22-28	D_1	d_1	D_1	Width of louvre
29-35	D_2	d_2	D_2	Width of louvre
36-42	E	Θ	E	$\angle \Theta$
43-49	ORGN		ORGN	Beginning point

APPENDIX II

PLANE GEOMETRIC METHOD

COL (3 Decimal)	INPUT CODE	SYMBOLIC CODE	HEADER CODE	COMMENT
1-7	A	ℓ	L	Starting width of louvre Program Increments dy .003
8-14	B	α	B	L α
15-21	C	K	K	Distance between louvres
22-28	D	H	HF	Starting height to be varied $\pm$ 10 by .25
29-35	E	a	A	Height up the panel
36-42	F	Θ	T	L Θ
43-49	G	M	M	Distance from panel

APPENDIX III

COMPUTER PROGRAM (a)

```
$JOB ALAF 1505  AA42  DR.  CHIOU
$OPTION 1 3
$OPTION 5
$EXECUTE FORTRAN
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
C  THIS PROGRAM CALCUATES VISIBILITY BETWEEN LOUVRES
C  STARTING WHERE VISIBILITY IS GREATEST AND GOING
C  UP FOR 20 INCHES ALSO GIVES GRAPH THROUGH THE
C  681.  ALSO IT GIVES  #  THAT CORRESPOND TO CURVE.
C  PAUSES  ARE  SET UP THAT WE MAY SET SCALE & SET PEN
C  THIS USES DR. CHIOU FORMULAR.......
CXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX
C  PY(I) & VIV(I) ARE MY X & Y
      DIMENSION PY(2000),VIV(2000)
      REAL KC,KD,K2,KA,KB,K1
C  ID1 & IV1 ARE MY X & Y IN SCALED FRACTION FORM FOR GRAPHING
      COMMON ID1,IV1
C  ICONV IS MAX SCALE FRACTION
      ICONV=2**31-1
CXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY
C  THIS PART OF THE PROGRAM SETS UP THE GRAPHING
      CALL INIT
      CALL SACN(1,IERR)
      ID1=IV1=0
      CALL LRDA(0,1,ID1,IERR)
      PAUSE ORIGIN
      ID1=ICONV
      IV1=ICONV
      CALL LRDA(0,1,ID1,IERR)
      PAUSE FULLSC
CXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY
      WRITE(6,91)
   91 FORMAT(1H1)
CABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABC
C  EACH OF THESE HAVE 4  DECIMAL PLACES
C             A = THE DISTANCE FROM THE PANEL
C             B = DISTANCE LUVERS ARE UP THE PANEL
C             C = DISTANCE BETWEEN THE LUVERS
C             D1 = WIDTH OF LOUVRE
C             D2 = WIDTH OF LOUVRE
C             E = ANGLE OF THE PANEL
C             ORGN IS NOT ACTUALY USED
CABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABC
    2 READ(5,1)A,B,C,D1,D2,E,ORGN
    1 FORMAT(7F7.4)
      IF(A)3,4,4
    4 CONTINUE
C  USED TO CONVERT DEGREES TO RADIANS
      EA=E/57.2957795
      T=90/57.2957795
C  HY & GY ARE THE HEIGHT UP THE Y AXES
      HY=(A+(B+C)/COS(EA))*SIN(T-EA)/COS(T-EA)
      GY=(A+B/COS(EA))*SIN(T-EA)/COS(T-EA)
      ORGN=ORGN1=GY
      WRITE(6,11)
   11 FORMAT('          A          B          C          D1          D2          E
     5   ORGN                    HY                    GY')
      WRITE(6,30)A,B,C,D1,D2,E,ORGN1,HY,GY
   30 FORMAT('0',7F9.4,10X,2F12.6)
      WRITE(6,31)
   31 FORMAT('0 I              PY(I)           VIV(I)    ')
      WRITE(6,8)
    8 FORMAT(' ')
C**********************************************************************
C**********************************************************************
C  THE CALCULATION OF X & Y IN THE FORM OF AN ARRAY TAKE PLACE HEAR
  800 CONTINUE
      DO 700 I=1,2000
      PY(I)=ORGN
  200 CONTINUE
      IF(HY.GE.PY(I).AND.PY(I).GE.GY)GO TO 300
      GO TO 400
  300 CONTINUE
      VII=1.0
```

```
      VIV(I)=VII
      GO TO 600
  400 CONTINUE
      IF(PY(I).GT.HY)GO TO 500
      GO TO 600
  500 CONTINUE
      KA=A+(B+C)*COS(EA)-D1*SIN(EA)
      KB=PY(I)-((B+C)*SIN(EA)+D1*COS(EA))
      K1=KA/KB
      VI=1-D1/C*(SIN(EA)/COS(EA)-K1)/(1+K1*SIN(EA)/COS(EA))
      VIV(I)=VI
  600 CONTINUE
      ORGN=ORGN+.01
  700 CONTINUE
C*******************************************************************
C*******************************************************************
    5 CONTINUE
C  YS   THIS IS PART OF SCALING
      YS=ORGN-ORGN1-.01
      DO 23 M=1,2000
C  ID1 & IV1 ARE MY X & Y IN SCALED FRACTION FORM FOR GRAPHING
      ID1=ICONV*(PY(M)-ORGN1)/YS
      IV1=ICONV*VIV(M)
      IF(VIV(M))9,51,51
   51 CONTINUE
  229 IF(.NOT.M.EQ.1.OR.M.EQ.2000)GO TO 232
      WRITE(6,7)M,PY(M),VIV(M)
    7 FORMAT(' ',I4,5X,F10.2,F12.6)
  232 CONTINUE
C  WRITING TO THE 681 & TO THE LINE PRINTER TAKES PLACE IN THE FOLLOWING
      CALL LBDA(0,1,ID1,IERR)
      IF(M.EQ.1)PAUSE PEN
   23 CONTINUE
    9 WRITE(6,7)M,PY(M),VIV(M)
      PAUSE LABEL
      GO TO 2
    3 CONTINUE
      STOP
      END
$ASSIGN1 LIB=HYALIB DIM=HYADIR
$ASSIGN2 5=SYC
$ASSIGN2 6=SLO,7000
$ALLOCATE 10000
$OPTION NOMAP
$EXECUTE GO
27.0,5.0,.01,.015,.015,55.0,0.0
27.0,5.0,.01,.018,.018,55.0,0.0
27.0,5.0,.01,.021,.021,55.0,0.0
27.0,5.0,.01,.024,.024,55.0,0.0
27.0,5.0,.01,.027,.027,55.0,0.0
27.0,5.0,.01,.030,.030,55.0,0.0
-000001
$EOJ
$$
```

APPENDIX IV

COMPUTER PROGRAM (b)

```
$JOB ALAF 1505  AAH1  DR. HOLLY AND E5 PARK
$OPTION 5
$OPTION NOMAP
$EXECUTE FORTRAN
CYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
C   THIS PROGRAM CALCUATES VISIBILITY BETWEEN LOUVRES
C   STARTING WHERE VISIBILITY IS GREATEST AND GOING
C   UP FOR 20 INCHES ALSO GIVES GRAPH THROUGH THE
C   681.  ALSO IT GIVES  #  THAT CORRESPOND TO CURVE..
C   PAUSES   ARE SET UP THAT WE MAY SET SCALE & SET PEN
C   THIS USES DR. HOLLY AND E4 PARK FORMULAS.......
CYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYYY
C   ID1 & IV1 ARE MY X & Y IN SCALE FRACTION FORM FOR GRAPHING
      COMMON ID1,IV1
C   ICONV IS MAX SCALE FRACTION
      ICONV=2**31-1
CXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY
C'  THIS PART OF THE PROGRAM SETS UP THE GRAPHING
      CALL INIT
      CALL SACN(1,IERR)
      CALL PENUP
      ID1=ICONV
      IV1=ICONV
      CALL LBDA(0,1,ID1,IERR)
      PAUSE FULLSC
      ID1=IV1=0
      CALL LBDA(0,1,ID1,IERR)
      PAUSE ORIGIN
CXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXYXY
      WRITE(6,240)
  240 FORMAT(1H1)
CABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDAB
C   EACH OF THESE HAVE 3 DECIMAL PLACES
C             A = STARTING WIDTH OF LOUVRE PROGRAM INCREMENTS BY .003
C             B = THE ANGEL OF THE LOUVRE
C             C = DISTANCE BETWEEN LOUVRE
C             D =HEIGHT OF PERSON TO BE VARIED  FOR 20 INCHES BY .01
C   BUT H IS THE CALCULATED LITTLE H
C             E =THE HEIGHT UP THE PANEL WHERE THE LOUVRE IS
C             F = THE ANGLE OF THE PANEL
C             G = THE DISTANCE FROM THE PANEL
CABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDABCDAB
    2 READ(5,1)A,B,C,D,E,F,G
    1 FORMAT(7F7.3)
C   USED TO CONVERT DEGREES TO RADIANS
      B=B/57.2957795
      F=F/57.2957795
C   N  IS USED AS THE STARTING POINT
      N=-2000
      IF(A)3,4,4
    4 CONTINUE
C**********************************************************************
C**********************************************************************
C             *   THE BIG DO LOOE INCREMENTS "A" THE WIDTH OF    *
C             *   THE LOUVRE..  THIS WILL DRAW THE DIFFERENT     *
C             *   CURVES..THE LITTLE DO LOOE DRAWS THE           *
C             *   CURVE  IT SELF..  TOGETHER THEY WILL DRAW 6.  *
C             ***************************************************
   99 DO 20 J=1,6
      K=0
      PLUS=(C+E)*SIN(F)+A*SIN(B-F)
      TAN=SIN(B-F)/COS(B-F)*(G+(C+E)*COS(F)-A*COS(B-F))
C   H=THE HEIGHT AT WHICH VISIBILITY IS 100%
      H=PLUS+TAN
      D=H-20
      D1=D
C*********************************************************************
      DO 23 M=N,2000
      IF (M)33,55,55
   33 CONTINUE
C   THESE ARE SET UP IN MY EQUATION FOR "V"
      DIV=A*(H-D)*(COS(B)/SIN(B)*COS(F)+SIN(F))
      DIVER=H*1/SIN(B-F)-A-E*SIN(F)*1/SIN(B-F)
      DIVER2=(D-H)*COS(F)*SIN(B)
```

```
C  V = THE VISIBLE PORTION BELOW THE LOUVRE  ..
      V=C-DIV/(DIVER+DIVER2)
      GO TO 66
   55 CONTINUE
C  THESE ARE SET UP IN MY EQUATION FOR "V"
      DIV=A*(D-H)*COS(B-F)
      DIVER=COS(F)*(D-A*SIN(B-F)-(C+E)*SIN(F))
      DIVER2=SIN(F)*(D+(C+E)*COS(F)-A*COS(B-F))
C  V = THE VISIBLE PORTION ABOVE THE LOUVRE  ..
      V=C-DIV/(DIVER+DIVER2)
   66 CONTINUE
      IF(V.GE.0)K=K+1
C  ID1 & IV1 ARE MY X & Y IN SCALE FRACTION FORM FOR GRAPHING
      ID1=ICONV*(D-D1)/40.01
      IV1=ICONV*V/C
      IF(IV1.LE.0)IV1=0
C          **********************************************
C          *  THE REST OF THIS PROGRAM IS FOR GRAPHING    *
C          *  PURPOSES, WRITING AND BRANCHING BACK ..
C          **********************************************
      CALL LBDA(0,1,ID1,IERR)
      IF(M.EQ.0)CALL DELAY
      IF(M.EQ.0)WRITE (6,230)D,V,M
      IF(M.GT.500.AND.V.LT.0)CALL DELAY
      IF(M.GT.500.AND.V.LT.0)GO TO 5
      IF(M.EQ.N)CALL DELAY
      IF(K.EQ.1)CALL PENDOWN
      IF(K.EQ.1)CALL DELAY
  229 IF(K.EQ.1)WRITE(6,230)D,V,M
  232 CONTINUE
      D=D+.01
   23 CONTINUE
C***********************************************************************
      D=D-.01
    5 CONTINUE
      WRITE(6,230)D,V,M
      CALL DELAY
      CALL PENUP
   20 A=A+.003
C***********************************************************************
C***********************************************************************
      GO TO 2
    3 CONTINUE
  230 FORMAT('0','  X=D=HIGH=  ',F9.4,10X,'Y=V=VISIBLE= ',F9.4,4X,I6)
      STOP
      END
CSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBS
C  SUBRUTINE THAT PICKS PIN UP PUTS PEN DOWN..  ALSO
C  SETS UP A  DELAY FOR PLOTING PUROPICES..
      SUBROUTINE PENUP
      CALL RSCL(15,IERR)
    2 DO 1 N=1,20000
    1 X231=0
      RETURN
      ENTRY PENDOWN
      CALL SSCL(15,IERR)
      GO TO 2
      ENTRY DELAY
      DO 3 N=1,300000
    3 X=0
      RETURN
      ENTRY DELAY2
      DO 4 N=1,20000
    4 X=0
      RETURN
CSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBSUBS
      END
$ASSIGN1 LIB=HYBLIB DIR=HYBDIR
$ASSIGN2 5=SYC
$ASSIGN2 6=SLO,7000
$ALLOCATE D000
$OPTION NOMAP
$EXECUTE GO
.015,90.0,.01,30.0,5.0,55.0,27.0
```

```
149   -0001
150   $EOJ
151   $$
```